

Review (Narrative)

Robotics in Modern Medicine

Where Will Medicine Go?

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SUMMARY

The major focus of this article is the application, uses and importance of robotics to modern medicine. As we all know that robotics is experiencing rapid growth in terms of modern medicine. To address this major point, a detailed research was conducted and compiled based on previous and current findings particular to this field. This includes notable achievements, early applications, recent innovations, applications and uses, important medical robots today, robotic dentistry and its application, ways by which robotics medicine has improved lives and finally, the future of robotics in modern medicine. All these factors address the issues stated above extensively. It is stated that robotics in application to modern medicine has indeed proved a worthy addition. Though the future of doctors is not yet certain, one thing for sure is medical robots in the nearest future will surely take over 75% of work required in medicine. ■

KEYWORDS

Robotics; Modern medicine; Substitution; Artificial intelligence; Future

Sci Insign Med. 2017;2017:e000144. doi:10.15354/sim.17.re097

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We are in the 21st century; the advancement in technology and high intelligence has skyrocketed. In every field of life, business, social, music, lifestyle and health, technology has almost taken over. In medicine, this also applies to various fields. In fact it has become very necessary and important to apply robotics to medicine. When it comes to x-rays, chemotherapy, radiography and lots more, robotics plays an important role. We have come to the stage where it is impossible to attain a reasonable amount of success and precision without the involvement of robotics. In this article, I'll be discussing all about robotics and modern medicine.

ROBOTICS

What is robotics all about? Before we go further into this discussion, you should first understand what robotics is all about. Let us quickly brief you on the basics of robotics. Robotics is an aspect or branch of science and engineering that deals with the design, construction, operation and usage of robots. The Robot Institute of America defines a robot as “reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of variety of tasks.” William Grey Walter invented the first electronic automated robot in Bristol, England in 1948 while the first digital and programmable robot was invented in 1954 by George Devol. In recent years, robots have played an important role in human life by making work easier and faster. Robots are largely used in dangerous conditions that can affect human life such as bomb detonation and removal of debris from unstable collapsed buildings. In this article, we will be focusing on medical robots.

MODERN MEDICINE

Medicine has always been a part of human development. Even in the early times when there was still usage of sub-standard equipment in medicine, the field of medicine has continued to evolve and advance, constantly requiring high level of precision. Modern medicine could be said to be the time interval for all medical research and inventions, from the year 2000 till date (1). A lot of research and notable innovation have been carried out and been successful. A few notable achievements are:

- The Human Genome Project was completed – 2000
- Creation of first bio-artificial liver by Dr. Kenneth Matsumura. – 2001
- Invention of Chitosan bandages by HemCon Medical Technologies Incorporated. – 2002

- Partial face transplant by Jean-Michel Dubernard. – 2005
- Argus II Retinal Stimulation System known also as ‘a bionic eye’ was created. – 2007
- First full face transplant by a team of 30 Spanish doctors. - 2010

In terms of drugs and medications, and even with the rise of complex and technical surgeries like heart transplant, kidney transplant, face transplant, lung transplant, liver transplant and so on, the need for high level of precision is required. Mistakes and errors made during surgery have led to numerous losses of lives. In a research, it was mentioned that if surgical errors were to be considered a disease it will be considered the 3rd most deadly disease in the United States. Doctors have been conducting lots of research in search to improve quality of surgery and reduce the rate of casualties. This is where robotics comes into play.

ROBOTICS AND MODERN MEDICINE

The first application of robotics to modern medicine was in 1985, a robot known as PUMA 560 was used to conduct a brain biopsy using CT guidance. Another early application of robotics to modern medicine was in 2001. A French doctor, Jacques Marescaux carried out the first Telesurgery in history. He did this on a patient in Strasbourg while he was in New York, USA by using a remotely controlled robot. A notable use of robotics in modern medicine occurred in 2009 when Dr. Stuart Geffner performed an all-robotic assisted kidney transplant at Saint Barnabas Medical Centre, New Jersey (2). Since then, many other inventions and medical robots have been introduced into the field of medicine. This has brought a lot of aid to the modern medicine in terms of small incision surgery, heart transplant, hygiene, human labor, costs of medication, higher level of precision due to robots capability to enhance vision in critical surgeries and numerous other ways.

Application and Uses of Robotics in Modern Medicine

There have been a lot of notable applications of robotics to modern medicine. Starting as early as 1985 many achievements have been made in terms of robotics and medicine (3-5). Here are a few notable applications of robotics to medicine.

- In 1985, the PUMA was used for the positioning of a biopsy cannula.
- Minerva robot was created in 1991 at the Lausanne, Switzerland. It was designed to direct tools into the brain under real-time CT guidance.
- The Renishaw Neuromate was cleared by FDA in 1997. It is used for deep brain stimulation, radio

surgery, transcranial magnetic stimulation, stereotactic electroencephalography and neuroendoscopy.

- ZEUS was created in 1995 by Computer Motion in USA. It was first tested on animals in 1996 before carrying its first tubal re-anastomosis and coronary artery bypass surgery (CABG) procedures in 2000.
- The Da Vinci was created in 2000 by Intuitive Surgical used to facilitate complex surgery and is being controlled via console.
- In 2006, three patients underwent robotic resection of the tongue base using Transoral Robotic Surgery (TORS)
- Pathfinder was created in 2004 by ProSurgics. It is used by the surgeon to specify a target and trajectory on a preoperative medial image, guiding the instrument into position, with submillimeter accuracy.
- Renaissance was created in 2011 by Mazor Robotics. It is used for spinal and brain surgery.
- Robodoc was created by Curexo Technology Corp, and first used in 1992 for a total hip replacement, and again used in 2009 for a total knee replacement.
- RIO robotic arm was designed in 2008 by MAKO Surgical Corp, and is used for the implantation of medial and lateral unicondylar knee components and also patellofemoral arthroplasty.
- Navio PFS was created by Blue Belt Technologies in 2012. It uses intraoperative planning for unicondylar knee replacement.

Robots are used in various ways and different functions in the hospital (6). Below are the major uses or applications of robots in modern medicine.

- **Transportation**

Robots are used to transport medications, supplies, meals and other delicate medical instruments around the hospital. This saves nurses the stress of carrying heavy loads around the hospital, an example of such medical robot is the TUG robot.

- **Disinfection of Hospital Surroundings**

Robots are used in hospital to disinfect and kill all microorganisms in the hospital environment which in turn reduces the risks of infection. With the use of UV light medical robots can effectively disinfect hospital wards within a very short period of time. An example of a disinfection robot is the Xenex robot.

- **Telepresence**

Doctors and physicians are now able to diagnose, treat and guide therapy over a long distance using telepresence robots. This could save the cost of transportation and lower risks of infection and

death in case a doctor has to travel far to attend to a patient.

- **Telesurgery** – See Robotics and modern medicine.

- **Rehabilitation**

These help patient with disabilities or paralysis related diseases like stroke, spinal cord injuries, and neurological diseases to recover fast. The RIBA is an example of such robot.

- **Diagnosis**

Now, robots have been made to diagnose certain conditions such as biopsy, brain tumors and other ailments. Some of these robots apply special features such as ultrasound 3D diagnosis. These could help doctors monitor and diagnose patients from a far distance.

- **Surgery**

Robots are used in surgery to enhance vision; an example of such robot is the Da Vinci Surgical System.

- **Therapy**

Robots are used in therapy, to aid recovery of patients. The RIBA is an example of such robot.

Types of Medical Robots

Medical robots are being split according to the specific function and tasks they carry out in the hospital (7-9). Below are the various types of medical robots.

- Disinfection robot
- Telesurgery robots
- Telepresence robots
- Rehabilitation robots
- Bio robots
- Diagnosis robots
- Surgical robots
- Pharmacy automation
- Therapeutic robots.

Advantages of Robotics in Modern Medicine

Robots have contributed largely to the field of medicine; so far the advantages surpass the disadvantages (10, 11). Here are a few advantages of robotics to medicine.

- Decreases pain and discomfort, this could be seen in the use of the Veebot to draw blood.
- Enhances vision during surgical operation.
- Smaller incision reduces risks of infection and diseases that could lead to death.
- Boost recovery of patients who undergo therapy.
- Decreases blood loss during transfusion.
- Improves hygiene
- Gives surgeons the ability to attain higher level of precision during surgical operation.
- Enhanced dexterity
- Reduces human labor and strenuous activity.
- Reduces cost of medication

- Helps doctors to access patients over long distances.
- Reduces large scarring by small incision.

Disadvantages of Robotics in Modern Medicine

In everything good thing, there is always a disadvantage. No matter how small. What are the disadvantages or side effects of robotics in modern medicine (13-16)?

- It is expensive to purchase.
- Requires large cost of maintenance.
- Operation requires highly professional trained personnel to operate them.
- Requires close proximity during surgery.
- Latency –slow response to instruction given by the surgeon.

Robotics and Dental Medicine

Robotics has played an important role in medicine, so also has it been a vital aspect of dentistry though in a different dimension (1-5). While in modern medicine, robots have been so effective that they have been applied in major fields of medicine such as surgery. This is not the same in dentistry, though numerous research and innovations are currently ongoing but effective application of robotics to dentistry is still in its tender age especially in the aspect of dental surgery. In dentistry, the most applied use of robotics is during training of students. Also, notable achievements in dental surgery based on robotics have been recorded (17). Though this falls under face transplant but replacing of the two jaws though under facial transplant, we will admit it is more related to dentistry than modern medicine. This limited progress may be due to the delicate and complex nature of the human dental structure.

APPLICATION AND USES OF ROBOTICS IN DENTISTRY

As said earlier, robotics has been applied mostly in dental training though robots have been made to aid dental surgery, research is still ongoing and in the near future, robotics will play a vital role in dentistry (17-19). Here are a few notable applications of robotics to dentistry.

- Showa Hanako invented by Showa University in conjunction with Tmsuk (a robotics company) in Japan designed to mimic human gestures and responses, giving dental students the chance to experience as if with a real patient.
- Geminoid DK was created by Professor Hiroshi Ishiguro and his team at Japan Advanced Telecommunication Institute International. This robot is able to mimic complex facial expressions and head motions.
- Simroid was designed at The Nippon Dental University, Kokoro. A special dental training robot

designed with high sensitivity able to feel simulated pain and discomfort during surgery, and give report on a students' performance after surgery.

- YOMI another remarkable innovation and contribution to robotic dentistry created by Neocis Inc in Miami and received clearance from food and Drug Administration (FDA) on March 2, 2017. It is a robotic guidance robot for dental implant surgery. It is designed to provide assistance in both pre-operative and intra-operative stages of dental implantation surgery. In other words, it helps to plan the procedures for the dental implant and assist during the dental implant surgery. This is the only robotic guidance system in dental surgery as of 2017.

IMPORTANT ROBOTS IN MODERN MEDICINE

Today, there are many medical robots around; many of them perform different functions in modern medicine. But there are few of them which are notable and are currently very important in modern medicine (17,18). This list is based on the efficiency and reliability of the robots, including notable achievements recorded by them.

- ***The Xenex Robot***

A disinfection robot used to disinfect and destroy all harmful microorganisms that cause Hospital Acquired Infections (HAIs) which has led to the death of 1 out of 9 patients according to a recent study. It does this by using Ultra Violet (UV) light to disinfect hospital environment. This has helped to reduce the risk of HAIs in patients thereby leading to a lower mortality rate. In fact, this has proved to be a very effective and efficient way of disinfecting health care centers as the robot can perform this activity repeatedly without getting fatigued, which is better than human sanitation which is prone to fatigue.

- ***The Da Vinci Surgical System***

Inspired by the great Leonardo Da Vinci, this is still to date one of the most reliable robotic surgical systems ever created (19). The Da Vinci is being fully controlled by the surgeon at all times, its magnificent features include micro wristed instruments that can achieve a high level of rotation, and a magnified 3D high-definition visual system. These features enhance vision, precision, smaller incision and control during surgery leading to a more successful surgical operation.

- ***TUG robot***

This medical robot does all the transportation of lab specimens, medications and other materials to various destinations in the hospital. It is controlled using a touch screen to navigate it throughout the hospital; this saves the stress of carrying heavy loads about. Unlike human nurses, the

TUG robot doesn't complain and can keep going for as long as possible, all it needs is to be recharged. The TUG is widely used in modern medicine.

- **RIBA (Robot for Interactive Body Assistance)**

The RIBA is very helpful for patients suffering from different forms of paralysis, rheumatism, and patients who need to be turned regularly to prevent bed sores. It is able to lift patients who weigh as much as 134lbs; this is made possible by its strong human like arms and high accuracy sensors. These features make it possible for the RIBA to assist patients into wheelchairs, turn patients repeatedly, and assist in locomotion around the hospital environments. The RIBA saves nurses the stress of turning patients repeatedly and the fact it doesn't get tired makes it highly efficient and reliable in medicine today.

- **Microbots**

The Microbot is another exciting and essential innovation in medicine today. Tiny robot less than a millimeter in size can now administer medication at an amazing speed to target organs where treatment is needed. When introduced into the body system, Microbots are able to propel themselves by using scallop swimming motion, they can move around in non-Newtonian fluids such as bloodstream, lymphatic system, and even slime on the surface of your eyeballs. Now, with this robot, drugs can be delivered to an exact location and operations like clearing of clogged arteries can be done. Microbots in the future will be able to treat diseases like cancer effectively.

- **Veebot**

This is a blood drawing robot; one of its magnificent features is that it can select the ideal vein suitable for insertion with an accuracy of approximately 83%. This reduces the risks of errors, infections and injuries to patients. 20%

of all attempts to draw blood fail on first trial, this fact could be eradicated using the Veebot.

Ways by Which the Application of Robotics in Medicine Has Improved Human Life

- It has reduced the risk of needle related infections and HAIs.
- It has led to more successful surgical operations.
- Increased the rate of patients' comfort in hospitals.
- It has reduced the rate of mortality in modern medicine.

FUTURE OF ROBOTICS IN MODERN MEDICINE

In the future there might be little or no need for doctors as medical robots will be able to perform all medically related activities. As seen in this article, medical robots are experiencing rapid growth in innovations, usage and application in modern medicine. Research is still ongoing and better robots will be designed in the future, robots able to treat cancer and perform surgery without or very little supervision. Now, the big question is, will there be need for doctors in the future? Robotic medicine is growing fast; surely robots will replace doctors in various medical fields but not all. Medical fields solely dependent on human doctors will still require humans. Aside from that, the future of doctors in medicine is gloomy (20).

In sum, medicine has evolved; the need for robotics is inevitable. The application of robotics to modern medicine has proved itself invaluable in the treatment of patients and performance of medical related activities in medicine. Scientists are still making positive progress in enhancing current medical robots and designing new robots with better quality and performance. With more advantages than disadvantages in medicine, I will conclude that, robotics in modern medicine is what it needs right now in this 21st century. ■

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Author Contributions: All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: All authors.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Wu H, Bao S and Xia F.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: N/A.

Obtained funding: N/A.

Administrative, technical, or material support: All authors.

Study supervision: Wang F and Xu S.

Conflict of Interest Disclosures: The authors declared no competing interests of this manuscript submitted for publication.

Funding/Support: N/A.

Role of the Funder/Sponsor: N/A.

How to Cite This Paper: Robotics in modern medicine: Where will medicine go? Sci Insigt Med. 2017;2017:e000144.

Digital Object Identifier (DOI): <http://dx.doi.org/10.15354/sim.17.re097>.

Article Submission Information: Received: September 30, 2017; Revised: October 24, 2017; Accepted: November 8, 2017

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